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THE UNIVERSITY OF ALBERTA

VISUAL DISCRIMINATION OF SIMILAR AND REVERSED LETTER PAIRS BY KINDERGARTEN, GRADE ONE, AND GRADE TWO PUPILS

by

© JAMES D. SMITH

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Visual Discrimination of Similar and Reversed Letter Pairs by Kindergarten, Grade One, and Grade Two Pupils submitted by James Dingle Smith in partial fulfilment of the requirements for the degree of Master of Education.

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DATE August 8, 1973

ABSTRACT

This study furthered research initiated by Popp (1964) concerning the confusability of specific alphabet letters, and was concerned with investigating whether there were significant differences among primary grade children in their ability to discriminate similar and reversible letters and whether differences would predict reading achievement. A further purpose was to determine if the confusability of these letters would change according to position in a word.

Ten visual discrimination tests of identical design were constructed with each test item containing one distractor. The test items ranged in difficulty from letters in isolation to letters located in words and nonsense syllables from three to seven letters. Significant differences were determined by observing the scores of one visual discrimination test in the presence of another visual discrimination test with the criterion variable a word recognition test.

The data for the study was gathered from seventy-five pupils, twenty-five in each of kindergarten, grade one, and grade two, from a public school in St. John's, Newfoundland. All tests were group tests, with the data analysed by Applied Multiple Linear Regression.

The findings indicated that the scores of the tests of similar letters were more frequently significant at the

kindergarten and grade one levels, while the tests of reversible letters were more frequently significant at the grade two level in predicting achievement on the word recognition test. Generally, visual discrimination competency increased with increase in grade level.

It was concluded that the ability to discriminate similar letters is distinct from the ability to discriminate reversible letters, and that visual discrimination of reversible letters is a more complex task than that of similar letters.

Therefore, more attention should be focused on the tasks of visual discrimination of confusable letters and on the development of exercises at primary levels to strengthen the skills for discriminating these letters.

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CHAPTER I

THE PROBLEM

1. INTRODUCTION TO THE PROBLEM

Early in the twentieth century educators became more noticeably concerned about the nature of the reading act. Part of this concern grew out of the developing awareness that the movement from non-reading to reading involved a series of difficult and complex learning activities. Early research sought to differentiate the skills involved in beginning reading and in so doing several important aspects of the reading process, one of which was called "perception" were identified. This initial concept was too generalized and obscure to be useful for describing beginning reading skills and, therefore, was accepted for a short time only, for it was immediately recognized that a number of skills were involved in the perception of words. In addition, the relationship which some of these skills had to reading was not clear.

The following sections will concern the reading process, word recognition in the reading process, and visual discrimination in word recognition.

The Reading Process

Reading may be described as follows (Gray, 1940): The good reader directs his attention to the printed page with his mind intent on meaning. He reacts to each word or group of words with a group of mental associations regarding the word form, its sound, and meaning. With the aid of these associations, he discriminates this word or word group from all others.

The words and word clusters are fused into thoughts as their meanings become clear. The reader, as he holds in mind each thought, analyses, synthesizes, and reacts, while reading through the sentence. The reader may retain many or all of the ideas of successive sentences, thus obtaining a clear impression of the author's intended meaning.

The reader may go beyond the literal meaning in reacting to ideas implied but not stated by the author, and in identifying the author's purpose, mood, and attitude toward the reader. Some of the ideas may be blended with the reader's previous experiences, and this fusion may result in more precise concepts which may become part of the reader's associations for future reading.

The reading process begins with the reader looking at the printed page; it includes the recognition of words, the understanding of sentences and paragraphs, the integration of meaning into the reader's past experiences, and reaction by the reader to the author's ideas.

Word Recognition in the Reading Process

Word recognition is that part of the reading process in which the reader sees and reacts to each word group with the intent of getting meaning. The process of recognizing printed words is complex and may vary from reader to reader. This study is concerned with that part of word recognition in which the reader discriminates between letters and groups of letters. The reader must be able to see clearly the letters or groups of letters representing the sounds and to differentiate each letter or group of letters from other letters. The process of differentiating among letters and groups of letters received through the visual sense is called visual discrimination. Visual discrimination is the detecting of likenesses and differences among letters and groups of letters.

Visual Discrimination in Word Recognition

Pop (1964) has pointed out that certain pairs of letters are more confusing to five year old children than are other pairs of letters. King (1972) in a comparison of two kindergarten groups concluded that early instruction in letter recognition was significant in predicting success in reading. Hill (1936) found that the location of letters in words may increase the confusability of the word. Further, Gibson, Gibson, Pick and Osser (1962) in a study tracing the development of visual discrimination stated that it is the distinctive features of grapheme patterns which are responded to in the discrimination of letter-like forms and the improvement in such discrimination is the result of learning to detect the invariants and becoming sensitive to them. They noted that awareness of topological transformations, rotations, and reversals, and line to curve transformations are critical for letter discrimination. It would seem apparent, therefore, that for word recognition one must consistently and accurately identify all letters. It would also seem apparent for word recognition that one must recognize these letters when they are located in words. The more accuracy which a child has in visually discriminating letters the greater should be his word recognition skill.

In beginning reading memory of word form may result in word recognition, but as the child is exposed to a number of words, words will frequently have similar configuration. Furthermore, in the beginning stages of instruction in word recognition, one should teach the child to look closely at the letters and sequences of letters which form words (Smith and Dechant, 1969; King, 1972) Failure to focus on the similarity of some word forms would result in incorrect identification of letters and sequence of letters. The child to become skilled in phonic and structural analysis must be able to discriminate letters and groups of letters of words accurately.

Visual Discrimination and Letter Confusability

Although Popp (1964) points out that there are two groups of letters which might confuse young children, there has been little research concerned which directly ascertains whether one group of letters would be more difficult for visual discrimination than another group of letters. Blair (1969) in a similar study of letter pairs with pre-reading children does point out that reversal and rotation transformation errors in letter pair comparisons occur most frequently. Money (1966, p. 27) argues that in learning to read a child must, among other things, acquire skill in the accurate identification of the position and form of letters and words. He identifies two concepts which the beginning reader must arrive at, and he calls these the law of positional constancy and the law of form constancy. Positional constancy refers to the fact that a letter, to retain its name must always be directionally oriented the same way. For example, if you change the letter "b" on a horizontal axis it becomes "p," on a vertical axis it becomes "d," on a depth axis (horizontal and vertical combined) it becomes "q." Money argues that beyond the recognition of individual letters, positional constancy also applies to the serial arrangement of letters in words: for example, reading "was" for "saw," or "on" for "no."

Form constancy dictates that alphabet letters to maintain their conventional role in communicating meaning must not transform their shape except within certain prescriptions. Omission or addition would be likely to change one letter into another in such transformations. Examples would be "h" and "n." Should the top part of the "h" be not observed, it would become an "n."

Money has indicated that among other things the development of these two concepts is necessary for accurate visual discrimination of letters and words. He does not indicate for primary grade children the relative complexity of these tasks. Form constancy requires that one recognize in letters size of line, shape of line, and the relationship of a line to one or more lines. Position constancy requires not only that one recognize form constancy but also, the relative position of the lines on an axis.

Letters which may be confused by adding or omitting lines may be called similar letters. Letters which may be confused by rotation on an axis may be called reversible letters. The ability to discriminate similar letters accurately may not be identical to the task of discriminating reversible letters. This does not mean that each task is distinct from the other, but rather that there may be an overlapping of skills necessary to perform each task as well as skills distinct for each task.

In summary then, should a child not discriminate accurately letters in words and sequence of letters in words, he would have difficulty with reading. The difficulty would be caused by the child's inability to be consistent in identifying letters and words that he sees. Furthermore, possible reasons for confusing letters and words of similar form may be that the child has not acquired the concept of form constancy. Reversible letters and words may be confused because the child may not have acquired the conceptual framework of positional constancy.

II. THE PROBLEM

Popp (1964) identified the pairs of letters kindergarten children confused who had not had pre-reading and reading experiences. The letters of a simple matching task which caused the most confusion to five year old children were two types and are listed below:

(1) reversible letter pairs --
    p-q, b-d, b-q, d-p, b-p, n-u.

(2) similar letter pairs --
    h-j, l-i, c-e, h-u, k-y, t-u, h-y,
    j-k, d-h.

Popp does not state that one group of letters might be more confusable for young children than the second group of letters.

Wheatley (1965) administered tests of geometric shapes, letters, and words to children who had not had pre-reading experiences; then, when the children were well into a beginning reading program, she administered reading tests. She, in trying to ascertain certain pre-reading skills which would be good predictors of reading achievement, found that children tend not to have difficulty in letter discrimination when the letters are in isolation; however, children do have difficulty discriminating letters when these letters are in words. Moreover, initial letter discrimination is a cue frequently used for word recognition (Burke, 1973), therefore, letter discrimination skill generally appears to be required for reading accuracy.

The problem is, then, that it is not known which type of confusable letters is more difficult for young children to discriminate, and whether a particular position of the letter in the word makes the task difficult.

III. NEED FOR THE STUDY

No study has been carried out as planned in this research for the purpose of investigating confusability of selected letters at kindergarten, grades one and two levels. Should children find these letters difficult to discriminate, learning to read may be more difficult.

IV. THE PURPOSE OF THE STUDY

It is the purpose of this study to assess visual discrimination ability of children at kindergarten, grades one and two levels for confusable letters in isolation, in words, and in nonsense syllables. A further purpose is to assess whether these visual discrimination abilities for confusable letters predict achievement on a word recognition test.

Since the letter pairs are of proven difficulty, and since the tasks were not beyond the experiential background of the children involved, any significant differences in test scores would probably indicate differences in ability to differentiate the confusable pairs.

It is generally agreed that of the many factors influencing word recognition ability among primary grade children, one could include sex, intelligence, and socio-economic status (Spache and Spache, 1969). In order to limit the effects of these factors, that part of the variance accounted for by sex and intelligence have been controlled statistically in some parts of the study. An attempt was made to randomize the effects of socio-economic status by selecting a school for the study which according to the considered opinion of local school authorities demonstrated a wide range of socio-economic status.

V. SIGNIFICANCE OF THE STUDY

Most developmental reading programs include, at the primary level, instruction in visual discrimination. It would be worthwhile to determine at which grade levels, kindergarten, grade one, or grade two, groups of children have difficulty in the visual discrimination of letters in isolation and in words. If errors in the identification of letters and groups of letters do exist at specific grade levels, the information would assist teachers in adapting instruction and materials in order to increase visual discrimination skill among children.

VI. TEST INSTRUMENTS

Introduction

The letters in the visual discrimination tests were considered in pairs; that is, a letter was matched with another letter with which it is confusable. The letter pairs were assessed for confusability in isolation, and when located in the beginning, middle, and ends of words. The letters were also located in nonsense syllables. Copies of these tests are contained in Appendix 1.

Similar letter pairs and reversed letter pairs are terms used in the hypotheses; these terms are defined under the heading "definitions." Since each hypothesis is stated in terms of the test instruments, a description of each test is included here prior to the statement of the hypotheses and is not repeated in chapter III. The letter pairs used in all test items are those letter pairs identified by Popp (1964) as being most confusable to young children. They are listed in Section II of this chapter, entitled THE PROBLEM.

The Visual Discrimination Tests

All ten tests have a matching to sample design and their composition is summarized in Table I.

Test I

In this test the items contain isolated letters and the purpose of the test is to determine the extent to which similarity of form creates a problem in the recognition of single letters:

e c e

Test II

The test items of this test contain isolated letters but the purpose of this test is to determine the extent to which confusion by rotating a letter on its axis creates a problem in the recognition of single letters:

d d p

TABLE I

COMPOSITION OF THE VISUAL DISCRIMINATION TESTS

Test No.	Test Name	No. Test Items	No. Times Confusable Letters Tested	Confusable Letters Tested
A. Similar Letter Pairs Tests			2	h-u t-u i-l e-c k-y d-h h-y h-n j-k
I	Single Letters	18		
III	Initial Letters in Three Letter Words	18	2	
IV	Initial Letters in Nonsense Syllables	18	2	
V	Letter Pairs Used together in Three Letter Nonsense Syllables	18	2	
IX	Larger Words as Initial, Medial and Final Letters	15	1 or 2	
B. Reversed Letter Pairs Tests			4	p-q b-p b-d d-p b-q n-u
II	Single Letters	24		
VI	Initial Letters in Three Letter Words	24	4	
VII	Initial Letters in Nonsense Syllables			
VIII	Letter Pairs Used Together in Three Letter Nonsense Syllables	24		
X	Longer Words as Initial, Medial and Final Letters	15	1 or 2	

Test III

Three or four letter words make up the test items. Initial letters only are changed in the distractor in each test item. The purpose of this test is to determine if locating confusable letter pairs of similar form in simple words would decrease ability to discriminate between such letters:

hat rat hat

Test IV

In this test the items contain three letter nonsense syllables with initial letters only changed in the distractor in each test item. The purpose of this test is to determine if locating confusable letter pairs of similar form in nonsense syllables would decrease ability to discriminate between such letters. The purpose of using nonsense syllables was to produce word forms in the test item which would reduce the use of meaning in the discrimination task:

hxt nxt hxt

Test V

The test items used three letter nonsense syllables. Two factors produced difficulty in this test: first, both letters of each confusable pair are included in each test item; second, the sequence of each confusable pair is switched in the distractor. The purpose of this test is to determine whether changing the sequence of similar letter pairs would decrease ability to discriminate between such letters.

uth htu uth

Test VI

The test items used three or four letter words in which only the initial letter of the distractor is changed. The purpose of this test is to determine if locating letter pairs, confusable due to reversal tendency, in simple words would decrease ability to discriminate between such letters:

bet det bet

Test VII

This test has items of three letter nonsense syllables. Initial letters only are changed in the distractor in each test item. The purpose of this test is to determine if locating letter pairs, confusable due to reversal tendency, in nonsense syllables would decrease ability to discriminate between such letters. Nonsense syllables were used to produce word forms in the test items to reduce the use of meaning in the discrimination task.

prs qrs prs

Test VIII

Three letter nonsense syllables and three letter words made up the items of this test. Two factors produced difficulty in this test: first, both letters of each confusable pair are included in the stimulus word; second, these confusable letters are interchanged in the distractor. The purpose of this test is to determine whether changing the sequence of the reversible letter pairs would decrease ability to discriminate between such letters.

pig pig gip

Test IX

The test items in this test have six, seven and eight letter words and beginning, middle and final letters are changed one at a time. The purpose of this test is to determine whether word letter length and location of letters would decrease ability to discriminate between similar letter pairs.

saying sahing saying

Test X

The test items containing six, seven and eight letter words have beginning, middle and final letters changed one at a time. The purpose of this test is to determine whether word letter length and location of letters would decrease ability to discriminate between reversible letter pairs.

express express exqress

Reading Achievement Test

The Gates Primary Reading Test (1958) Type PWR, Word Recognition, Form 1, hereafter called The Gates Word Recognition Test, was used to assess word recognition skills. This test consists of 48 items each of which contains four printed words and a picture which illustrates the meaning of one of them. The task is to circle the word that explains the picture. The test measures the degree to which students can identify representative words.

Intelligence Test

The Lorge-Thorndike Nonverbal Intelligence Level 1, and Level 2, Form A, Primary Battery Tests were used. These tests hereafter are called The Lorge-Thorndike Intelligence Tests. It was recommended in the manual that Level 1 be administered to kindergarten and grade one classes, and Level 2 to grade two classes.

In hypotheses I and II the visual discrimination tests are considered in pairs. Statistically, this means that in assessing significant differences, each visual discrimination test will be looked at in the presence of another visual discrimination test. For example, in hypothesis I, Test III will be considered in the presence of Test IV then in the presence of Test V; Test IV will be considered in the presence of Test V.

VII. HYPOTHESES

Hypothesis I

When differences attributed to intelligence and sex are controlled, there is no significant difference between a child's ability to discriminate selected similar letter pairs on each of Tests III, IV, V and his score on *The Gates Word Recognition Test*:

(A) for the total test sample
(B) for kindergarten children
(C) for grade one children
(D) for grade two children

Hypothesis II

When differences attributed to intelligence and sex are controlled, there is no significant difference between a child's ability to discriminate selected reversed letter pairs on each of Tests VI, VII, VIII, and his score on *The Gates Word Recognition Test*:

(A) for the total test sample
(B) for kindergarten children
(C) for grade one children
(D) for grade two children

Hypothesis III

There is no significant difference between a child's ability to discriminate selected similar letter pairs (total score of Tests I, III, IV, V, IX) from his ability to discriminate selected reversed letter pairs (total score of Tests II, VI, VII, VIII, X) as reflected in scores on The Gates Word Recognition Test:

(A) for the total test sample

(B) for kindergarten children

(C) for grade one children

(D) for grade two children

Hypothesis IV

There is no significant difference between a child's ability to discriminate selected similar letter pairs located in longer words (score of Test IX) from his ability to discriminate selected reversed letter pairs in longer words (score of Test X) as reflected in scores on The Gates Word Recognition Test:

(A) for the total test sample

(B) for kindergarten children

(C) for grade one children

(D) for grade two children

Hypothesis V

The scores of the children on all of the tests intended to measure the ability to discriminate selected letter pairs (total score of Tests I to X) do not account for a significant amount of the variance of the scores on The Gates Word Recognition Test beyond that difference accounted for by intelligence:

(A) for the total test sample

(B) for kindergarten children

(C) for grade one children

(D) for grade two children

Hypothesis VI

Grade does not account for a significant amount of the variance of scores on The Gates Word Recognition Test beyond that variance accounted for by the scores of the children in the tests intended to measure the ability to discriminate selected letter pairs in longer words (scores of Tests IX and X).

Hypothesis VII

There is no relationship between sex and visual discrimination (total score of Tests I to X).

VIII. LIMITATIONS

The ten visual discrimination tests were constructed by the researcher to measure the ability of children to discriminate between selected pairs of letters. Limitations are acknowledged as follows:

1. Measures of reliability were not applied to the visual discrimination instruments because these tests were too short even though the letter pairs were repeated at least twice in most tests.

2. Only one alternate answer was used for each test item in addition to the correct answer because of the young age of the subjects thereby increasing the probability of guessing.

3. Pupil scores on The Visual Discrimination Tests were high at all grade levels. This limits interpretation of the analyses. The pupil raw scores are not contained in the analyses.

IX. DEFINITION OF SPECIAL TERMS

Visual Discrimination -- Visual discrimination is the detecting of likenesses and differences between pairs of letters

Similar Letter Pairs -- These are letters which may be confused due to similarity of form, that is, one letter may be confused with another by adding or omitting lines. An example of a similar letter pair would be "h" and "n."

Included as similar letter pairs are letter pairs which to be confused would include a reversal error along with an error in formal similarity. For example, to confuse the letters "h" and "u," a reversal error is required, as well as an error by adding a line. Such letters requiring more than reversal errors to be confused will be classified as similar letter pairs in this study.

The similar letter pairs in this study are: h-u, i-l, k-y, t-u, e-c, d-h, h-n, h-y, j-k.

Reversed Letter Pairs

Reversals are the confusing of letters which are identical when rotated on an axis. Reversals may be classified according to three types of rotations:

1. the rotation about a vertical axis, e.g., b-d.
2. the rotation about a horizontal axis, e.g. b-p, d-q.
3. the rotation about a depth axis, e.g., d-p, b-q, n-u.

X. THE EXPERIMENTAL SETTING

The experimental design is reported in detail in Chapter III. A summary is presented here.

The stratified, random sample used in the study consisted of seventy-five children selected from those attending Mary Queen of Peace School in St. John's Newfoundland. At the time of testing, March, 1967, the kindergarten classes were two months advanced on a reading program. Twenty-five of the children in the sample were from kindergarten, twenty-five from grade one, and twenty-five from grade two.

Ten visual discrimination tests were administered to the groups in order to test the hypotheses in the study. The Gates Word Recognition Test was administered to assess reading achievement and The Lorge-Thorndike Intelligence Tests so that where necessary intelligence variables would be controlled statistically.

The data collected were analyzed at the University of Alberta, Edmonton, using a multiple linear regression program to measure significant variances among the selected variables contained in each hypothesis.

XI. ORGANIZATION OF THE REPORT OF THE STUDY

Chapter II contains a review of the literature relevant to the visual discrimination of alphabet letters. There has been considerable research in visual discrimination and its relationship to reading. Many of these studies were concerned with various types of geometric figures. This study, in the review of research, will be concerned primarily with alphabet letters and words on "pencil and paper" tests of visual discrimination. Some attention will be given to research in visual discrimination that was not concerned directly with letters and words, but which indicate some implications for the visual discrimination of letters and words at the primary levels.

Chapter III presents a description of the experimental design, a description of the testing procedures and the statistical procedures used in the analysis. Chapter IV contains a presentation of the findings. Chapter V contains a summary of the findings, conclusions, implications and suggestions for further research.

XII. SUMMARY

Some children have difficulty with reading. This difficulty may be caused by the child's inability to be consistent in identifying letters and words he sees. Similar letters and words, and reversible letters and words would be confused. The purpose of this study ~~is~~ to assess visual discrimination ability of primary grade pupils by observing their abilities to discriminate between letter pairs of proven difficulty in isolation and in words and nonsense syllables.

Included in Chapter I is an introduction to the problem, significance of the study, the hypotheses, limitations, definition of special terms, and the experimental setting.

CHAPTER II

RELATED RESEARCH IN VISUAL PERCEPTION

1. INTRODUCTION

Chapter II will include, first, a review of a current theory concerning visual discrimination, and second, a review of research relevant to the discrimination of letters and words.

Durrell and Nicholson (1961) feel that there are three essentials for progress in reading. One of these essentials is that the child be able to notice separate sounds in spoken words. If the child cannot do this, he will not be able to relate the sounds to the printed letters.

A second essential ability for learning to read is the ability to see differences in printed letters and word forms. It requires close discrimination to notice the differences between b, p, d, and g. The child who cannot tell letters apart or notice the differences in word forms will have trouble in relating sounds to the letters and words.

A third ability is observing the relationship between letter forms and the sound of the letter. When the relationship between visual and auditory elements of words has been established, the acquisition of sight vocabulary progresses rapidly.

This study will be concerned with the second essential ability in the reading process, the ability to see likenesses and differences in printed letters.

II. A CURRENT THEORY IN VISUAL DISCRIMINATION

Money (1966, pp. 21-25) proposes three constancies which would influence a child's ability to discriminate words and letters. He feels that the pre-reader lives in a jungle of camouflage, learning during his pre-school years that objects retain their same identity and meaning irrespective of transformations and disguise. Without changing its name or significance, an object may take on a different visual form by rotation to any point on the compass. It may be dismembered, or subtracted from. It may be embellished and added to. Nevertheless, the object has the same designation and meaning. The object obeys the law of object constancy. Money argues that learning to read turns the pre-reader's conceptual world of object constancy into chaos, for it supplants and supplements the law of object constancy with the law of directional constancy and the law of form constancy.

In learning to read and write, the law of directional constancy applies both to letters and to their arrangements in words. An alphabetic letter, to retain its name and conventional role in communicating meaning, must always be directionally oriented the same way. Errors in letters and words may occur when they are rotated on either a vertical, a horizontal, or a depth axis. Money also argues that the law of directional constancy applies to the syntactical arrangement of words in sentences as well as to the serial arrangement of letters in words.

The law of form constancy dictates that a letter to retain its meaning, must not transform its shape except within certain prescriptions. Omissions or additions are likely to change one letter into another in such transformations. Money reported that the application of form constancy is extremely inconsistent. The beginning reader must differentiate capitals from lower case, and also variations of font. It is also necessary to distinguish and equate print and cursive script. Recognition of all these differences and equalities, added to those pertaining to directional orientation, constitutes a very complex task for the young reader.

Money's theories of constancy are related to this study, since it is felt that any significant difference in the ability to discriminate letters and words of similar form, and reversible letters and words, would support the idea that for accurate visual discrimination of letters and words, one must possess a clear concept of form constancy. Furthermore, the application by Spache and Spache (1969, pp. 13-15), of Vernon's (1962) theory of perception to reading gives considerable attention to object constancy and its application to reading. However, no consideration is given by Spache and Spache to the possible influence of form and positional constancy upon visual discrimination of letters. The similar and reversed letter pairs used in this study come within the framework of Money's laws of form and positional constancy respectively. Gibson, Gibson, Pick and Osser (1962) sought to trace the development of discrimination of letter-like forms in children four to nine years old, paying attention to the kinds of transformations that were hard and easy to discriminate at different age levels. Geometric forms were constructed with the following transformations represented: line to curve, reversals, perspective transformations, and rotations. The results showed that errors decreased from age four to eight, but rate of decline was quite different for different types of transformation. Errors for break and close started low and dropped to near zero by eight years. Errors for perspective transformations started high and remained high. Errors for reversals started high but declined rapidly. The authors felt that reversal errors do not serve as distinctive feature errors, since an object is seen to remain the same object if it is turned, and what the child learns is to perceive its permanence despite change in position. This study may be related to the confusable letters of the present study as follows: reversals -- p and q; b and d; breaks and closes -- o and c; c and e; l and i; rotations -- n and u; d and p; reversals and rotations -- b and p.

III. A REVIEW OF RELEVANT RESEARCH

Early Research in the Perception of Letters and Words

Early research concerned with the discrimination of letters and words was conducted by Smith (1928) and by Gates (1926). Smith argued that general ability in word recognition cannot progress very far until pupils have developed the particular ability of making visual discriminations, at least to the extent of being able to match word forms. She found a correlation of .87 between ability to match word and letter forms and reading ability of 200 first grade children in a Detroit school. The most difficult letters children found in the letter matching test were -- b, p, q, and d. She found, also, that children of low intelligence made more errors in matching letters than did children of high intelligence. Included in this study was an attempt to determine the effect which the different letters had upon matching when combined into groups as they would appear in words. These tests were of three types: (1) hard letters (as assessed in the matching test) at the beginning and end of words; (2) easy letters at the beginning and hard letters at the end of words; (3) hard letters at the beginning and easy letters at the end of words. She found that a word both beginning and ending with a hard letter is not necesarily harder to match than one which begins with an easy letter and ends with a hard letter.

Significant in Smith's study was her realization that imbedding a letter in a word might add significantly to the difficulty of the letter as determined by a simple letter matching task.

In the present study, letters are considered both in isolation and when imbedded in words and nonsense syllables.

Gates (1926) began a series of experiments in perception and reading which ran through a number of years. The early studies were an attempt to identify perceptual abilities influencing success in reading. Relevant to his early studies was research in geometric shapes as they related to reading ability. These early studies of Gates indicated that the ability termed "word perception," one part of which is the ability to detect small differences in words, bears a close relation to reading. Intelligence had a correlation slightly below the word perception ability and tests of the perception of digits and geometric figures had low but significant correlations with reading. Of major concern is Gate's conclusion that there is not a particular perceptual ability, but rather a number of perceptual abilities involved in reading. This supports Money's laws of constancy which are considered in this study.

Gates and Bond (1936) conducted a study of four large classes of children who were given instruction in reading soon after entering first grade. Among the tests given were the following: tests of naming the alphabet, letters, reading letters, matching words, looking at a word and comparing it to words similar to it in order to pick from these words the initial word, form matching. All tests but the form matching tests, that is, all verbal tests gave significant correlations with ability to learn to read. Letter and word matching tasks are contained in test instruments of this study.

Hill (1936) conducted an analytical study at the beginning level with normal readers investigating some types of errors in word discrimination. Among the tests given were "cues" tests in which the emphasis was upon the use of certain aspects of words as cues for the recognition of whole words. The factors which Hill considered might be operating as inadequate cues were the beginning, middle, end, beginning and end positions of words, the configuration of words, and additions and omissions of letters. From an analysis of the data she concluded that the beginnings and endings of words were more frequently used as cues than the middle.

A second type of test administered were "details" tests. These required discrimination of letters in isolation and when imbedded in words. Significant among her conclusions were the following: the letters contained on the tests when presented in isolation caused little trouble; configuration was not significant; the order of letters gave rise to a relatively large number of errors.

The third type of test administered were "organization" tests involving the letters p, q, b, d, n, u, in three types of tests: letter discriminations, discriminations between words in which only one letter was placed in a different orientation and the discrimination of words in which letters were completely omitted. She found a continuum from practically no discrimination ability to accurate discrimination in the letter forms test. Also reversible letters appearing in words cause more difficulty in discrimination than those same letters appearing in isolation.

Several points could be noted concerning Hill's study. She along with Smith (1928) does indicate that imbedding the letter in a word seems to be more significant in predicting the confusability of the letter in reading rather than determining letter confusability simply by comparing to other letters. Hill does not use words but rather nonsense syllables, in order to lessen use of meaning and familiarity with word to discriminate. It would seem that achievement is an important consideration in that the individual may build up facility in discrimination of letters in known words.

By considering selected letters in isolation and also imbedding them in nonsense syllables, this study attempts to further support the observations of Hill.

Pretty (1939) conducted a study of certain factors influencing reading readiness. Among the tests given was an adapted form of the Lee-Clark Reading Readiness Test. This test involved matching of letters and matching pairs of words which were identical except for the inclusion of one superfluous letter in the second word of each pair. This test correlated fairly highly with reading achievement. Pretty concluded that apparently a child must be able to distinguish between visual sensations of the kind experienced in reading. Otherwise he is unable to deal with printed symbols and is not ready to learn to read. Pretty's study adds no new knowledge over and above the preceding studies but does support previous studies and this study.

Reversibility and Success in Reading

Since this study is concerned in part with reversed letter pairs, the following studies are related in that they indicate that the tendency to make reversal errors is related to reading achievement.

Krise (1949) used a group of college students in a study of tendency to make reversal errors. He hypothesized that, when confusion occurs with symbols which are identical when the background is disregarded, this confusion is due to a lack of familiarity with the relationship between the various symbols and their background. In the study, one symbol was chosen to represent the four letters i, a, e, and o when rotated. The college students were also required to learn non-reversible symbols. It was found that the college students required more time to remember correctly the reversible symbols than to remember the non-reversible symbols. Krise attributed this difference in time to the confusion caused by the reversible characteristics of the symbols substituted for vowels. Krise argued that reversals are primarily caused by the fact that students simply find it difficult to differentiate among symbols which are similar. Krise argued that there might be a need for making students more familiar with reversible letters. It is also hypothesized in the present study that reversible letters cause more difficulty for primary pupils than do non-reversible letters.

Potter (1949) investigated perception of symbol orientation and early reading success. Several of her findings are reported in Traxler (1955), Townsend (1951), Feldmann (1961), and Wheatley (1965). Pupils were tested on their ability to perform the following tasks: match two, three and four letter combinations; match representational and geometric shapes; copy shapes. Analysis of these tests revealed the following: many children beginning to read had good word perception; ability to avoid reversal errors was found to be a crucial ability for early reading success, a finding which supports this study; relationship between copying shapes and matching ability remains fairly high when mental age is controlled.

Feldmann's reversal test contained the same weaknesses as the reversals test which was used by Potter (1961). Feldmann used an adapted version of Potter's reversals test.

Wohlwill and Weiner (1964) investigated the question of children's ability to differentiate stimulation on the basis of their orientation by employing a matching-from-sample task, in which the subject was first trained to respond to one of two stimuli which matched a sample stimulus. The subject was then presented with a series of test trials in which one choice stimulus was identical with the sample while the other was the left-right or upside down reversals of the same figure.

Twenty-four children between the ages of forty-seven and fifty-six months were involved in the experiment. Significant among the results of the study is the finding that children as young as four to five years old have little difficulty, on the average, in discriminating stimuli on the basis of their spatial orientation, provided the task requires an orientation selective response to this.

It should be noted in considering the relevancy of this study to a discussion of reversals in reading, as Wholwill does point out, that letters differ in important respects to the figures used in the study. Letters are smaller and topologically more complex than the figures he used.

Twohig (1972) in a study of the relationship between body directionality, letter directionality, and reading achievement at the grade one level found that the ability to discriminate directionality in terms of one's own body and with reference to alphabetic letters in isolation, words and sentences, appeared to be positively correlated with reading accuracy achievement supporting the use of reading achievement as the criterion variable in the present study. Further, analysis of the proportion of errors indicated that the lower reading group displayed a greater tendency for global directional confusion (left-right, vertical, combined), while the errors made by the higher reading groups tended to focus more on a left-right gradient. There was also significant difference between the scores obtained by the high, average and low reading achievers on the letter directionality test. Since this seems to point out that intelligence is a significant factor in directionality discrimination, intelligence is controlled statistically in this study.

Studies of Letter Pair Confusability

The purpose of Popp's (1964) study was to determine which pairs of alphabet letters were most often confused by pre-reading children and therefore be most likely to cause confusion in initial reading instruction. Sixty-five children, ranging in ages from five years and one month to six years and one month, attending a public kindergarten, were divided into five groups of thirteen subjects each with an even distribution of chronological ages within groups. Testing was done in early February before the children had had formal training in letter matching or other pre-reading instruction. Standard two-choice items of matching to sample design were constructed, making twenty-five items for each letter and a total of 650 items. The children made a total of 1186 errors with the following pairs being most frequently confused: p-q, b-d, b-q, d-p, b-p, h-u, i-l, k-y, t-u, c-e, d-h, h-n, h-y, j-k, n-u.

Popp concluded that consideration of the distinctive features and of the formal similarity of letters should provide insight for training a specific skill in visual discrimination of letters.

The matching and sample design used in the present study is adapted from the design used by Popp. The selected similar and reversed letter pairs were those determined by Popp to be most confusable for young kindergarten age children. Further references to Popp's study follow in other parts of this study.

Blair (1969) in a study similar to that of Popp used two samples of children with both being tested before receiving formal instruction in reading. One sample consisted of fifty children with a median age of six years, zero months, who attended a public kindergarten in a lower-middle class community. The second sample consisted of twenty-five children, with a median age of four years, four months, who attended a public nursery school supported by a leading university in an upper-middle class community.

A total of 650 three inch by five inch cards were presented in five sets of 130 cards in matching to sample tasks. The pupils were divided into five groups with each group receiving a different set of cards. There were no significant differences in the error score between the five groups across the two samples. However, there was a significant difference ($p < .01$) in the error scores between samples indicating that the kindergarten children had fewer errors than the nursery children. The author notes that the error rate and type of error of Popp's (1964) sample of kindergarten children is more similar to the sample of nursery school children than to the kindergarten sample. This study supports the letter pair selection and the matching to sample design of the test instruments of this present study.

Visual Perceptual Abilities and Reading Achievement

The present study is concerned with the visual discrimination of selected similar and reversed letter pairs in predicting reading achievement and the following studies concerned with visual perceptual abilities and reading improvement are related to it. These studies generally support the argument that the visual discrimination of letters and words is vital for reading success.

Harrington and Durrell (1955) were concerned with certain perceptual factors and reading. Visual discrimination tests were administered by having students look at a flash card and then select the word in a multiple choice situation. They found a significant correlation between visual discrimination and the reading test. The authors concluded that specific instruction in phonics and in visual and auditory perception of word elements is essential in building reading vocabulary in primary grades.

A second study concerned with factors predicting success in first grade reading was conducted by Durrell and Gavel (1958) in which two thousand students participated. On a letter matching test administered in September it was found that a significant number of students could match most of the letters, and hence it was felt that letter matching abilities were not predictive of reading achievement. This supported some of Gates previous research.

Goins (1958) carried out a detailed study of the relationship between visual perceptual abilities and success in learning to read with 120 first grade children in Chicago. Her study was not concerned with letter or word matching, but with pictures and geometric forms, yet it is interesting on the basis of her conclusions. Students were given perceptual tests and the Chicago Reading Test. Then they were given perceptual training, following which, perceptual tests and a reading test were administered a second time. Among the conclusions arrived at, the following are pertinent to this present study:

1. There were various types of perceptual abilities and degrees of competence.
2. The data secured from the reversals test supported Krise's (1949) argument that reversal errors in reading were a problem in visual space perception.

Goins did not include any "verbal" material, that is, tests that utilized words, syllables and letters, since these tests would only separate the readers from the non-readers at the grade one level.

Another intensive study concerned with perceptual factors in reading was conducted by Malmquist (1958) in

Sweden on 365 grade one students in two communities. Among the tests included were: geometric figures, letters, digits, geometric configurations, pictures. The research findings from this study indicated that the ability to distinguish between letters and numbers was more closely related to reading ability at the first grade level than the ability to distinguish between geometric shapes or the ability to distinguish pictures. Malmquist expressed agreement with Gates (1926) that perception was not a unitary function, but rather would vary with different types of reading materials.

Malmquist's Visual Perception Test of Letters, though helpful in determining letter matching as a general factor in the relationship between perception and reading, would not isolate particular skills in the visual discrimination of letter words. This was due to the diversity of design of the test items. The test items in the present study are a simple matching to sample design with one distractor.

Feldmann (1961) attempted to re-examine the conclusions from previous research by investigating the development of visual perception skills and the relation of those skills to reading. Ninety-five children at each level from kindergarten through grade five, were measured on tests of intelligence; three visual perception tests -- the Bender Visual Motor Gestalt Test, the Gestalt Completion

Test, a Reversals Test; two reading tests. In that this was a developmental study it was concerned with visual perception skills in relation to age. Data analysis indicated that general visual perception, form sequence and orientation skills were related to reading at all grade levels assessed.

In the Reversals Test a three letter nonsense syllable was printed alone on a page. The child was allowed to look at it for an unlimited time, and then had to locate it among four nonsense syllables on another page. Feldmann mentioned that the three distractors were of a specific form: in one the original letters were in exact reversed sequence; in another the letters were in mixed sequence; in the third the sequence was correct but one letter was reversed in direction. The obvious weakness of this test was that unless you looked at each child's response on each test item you would not know the exact error made. For that matter, all the errors made by all the children in the sample could have been errors in sequence and not errors in reversals.

Wheatley (1965) examined the relationship existing between certain visual discrimination abilities at the pre-reading stage and achievement in reading at the end of first grade. The subjects consisted of 102 first grade pupils attending three public schools in Edmonton. The visual discrimination tests constructed by Wheatley included: form rotations, reversals, configurations, pattern details, letters, and words.

Correlation coefficients were computed to determine the relationship between the visual discrimination abilities tested and reading achievement. A comparison made between the six form discrimination tests and the six letter and word matching tests indicated that word and letter matching ability was more closely related to reading ability than form matching ability. Correlations also revealed that word reversals was significant in predicting reading achievement at the .05 level of confidence. They further revealed that letter matching was significant in predicting reading achievement at the .01 level of confidence. Wheatley did not identify selected letter pairs which would be confusable when located in words.

Barrell (1965) was concerned with the controversial reports as to whether visual discrimination of letters or visual discrimination of words best predicted first grade reading achievement. Investigations by Smith (1928), Wilson (1942), and Gavel (1958) provided support for the position that reading readiness tasks requiring visual discrimination of letters best predicted first grade reading success. On the other hand, the work of Gates, Bond and Russell (1939) indicated that visual discrimination of words was the most valuable predicator of first grade reading achievement when compared to the other visual discrimination tasks.

Barrell in a study of 724 students in 26 first grade classes attempted to determine whether visual discrimination of letters or words was the best predicator of reading success. He concluded that word matching should be included in an optimum combination of visual discrimination tasks for predicting first grade reading achievement. Thus he supported the position of Gates, et al. (1939).

Barrell also found in support of Goins (1958) that reversals measured a type of visual ability which was useful to predicting first grade reading achievement.

Burke (1973) undertook to explore which cues children used to recognize words visually. When a child attempted to pronounce a word regardless of whether phonics, or the "look and say" method had been stressed, he must remember some prominent cue in the word which would enable him to recall it when he met it again and attempted its pronunciation. The sample consisted of 48 grade one children who were of average IQ with an equal distribution over sex and reading achievement level. The results showed that initial letters were most frequently used as cues to word recognition while shape was least used. Though the use of initial letters as cues was a limited word recognition skill, it was evident that this skill required accurate visual discrimination of letters.

Two hundred students (Smythe, et al. 1970) enrolled, approximately fifty per grade, in kindergarten and grades one through three, were the subjects in an examination of the development of children's knowledge of both upper-case and lower-case letter names. The pupils were assigned to one of four chronological age groups, 65-76, 77-90, 91-104, and 105-132 months. The letter naming tests were administered individually to each student.

Performance on the lower-case naming test was generally poorer than that on the upper-case naming test, but most pupils had almost completely mastered the lower-case naming test by the end of Grade Two. This supported the grade selection for the present study.

Since Smythe et al. (1970) found that age groups one and two above had higher discrimination scores for the upper-case letters than for the lower-case letters, a rank order correlation was calculated between the percentage of group one and two pupils correctly discriminating each letter. Separate calculations were made for upper- and lower-case letters with $p > .50$ for upper-case letters and $p < .05$ for lower-case letters. The ability to discriminate letters was included in the naming task, but the study showed the relationship between these two skills was significant only with respect to lower-case letters.

This supported the selection of lower-case letters for this study.

Visual Discrimination Training and Reading Improvement

The present studies concerned with the visual discrimination of selected similar and reversed letter pairs and the following studies concerned with training in the visual discrimination of words and letters gave background information which supported the decision in the present study to use confusables.

King (1964) compared six groups (twenty-three in each) of kindergarten children learning to read four words following different kinds of visual discrimination training. The learning tasks of the groups were as follows:

1. Successive presentation of different meaningful words from future reading task words along with the presentation of visual forms, sounds and pictures.
2. Successive presentation of different words from the reading task words; but no presentation of picture or sound.
3. Successive presentation of the same letters which were constituent of reading task words.
4. Successive presentation of the same words as the reading task words.

5. Simultaneous presentation of words which were the same as the reading task words.

6. Successive presentation of geometric forms.

King was interested in examining the effect of three specific variables in visual discrimination training on learning to read words. The following three questions were raised:

1. Does a set to associate words with sounds and meaning during visual discrimination training enhance performance in learning to read words compared to discrimination training with words that are not associated with such responses?

This question was answered positively at the .01 level of confidence.

2. Does visual discrimination training with individual letters or whole words better prepare children for reading a word list which includes the same letters and words that were used in the training? This question was also answered positively with $p < .01$. Pertinent to this question, the results showed that matching all the single letters which were constituents of the words to be learned later in the reading task was more effective for learning than training in matching the same words which were to be learned.

3. Is a simultaneous or a successive method of presenting a set of words in visual discrimination training more effective preparation for learning the same set of words? The question showed neither to be superior and hence was not significant.

On the basis of this experiment, King suggested that pre-reading and beginning reading programs be modified to include visual discrimination training with the easier task of matching single letters to be followed by the more difficult but effective training in discriminating words made meaningful by associating appropriate sounds and meaning with the visual forms.

King's study was relevant in that she seemed to support previous conclusions that there are a variety of perceptual abilities. However, King seemed to indicate, too, the developmental nature of skills involving visual discrimination in that she suggested training in letters then in words containing these letters. Once children became familiar with cues necessary to discriminate letters they would use these cues to discriminate letters in the more complex situations of recognizing meaningful words.

King (1965, pp. 337-340) in a study of non-reading kindergarten children determined the effects of visual discrimination training with different types of stimulus materials and different methods of stimulus presentation on performance in a transfer task consisting of learning to read a list of words.

Conclusions arrived at were that superiority of visual discrimination training with meaningful word forms over word forms with no meaning may be attributed to one or more of the following factors: (1) training was provided in acquiring a set of discriminating responses which included verbal labels; (2) training was provided in applying verbal labels consistently; and (3) training was provided in responding to word stimuli in a threefold manner similar to that required in learning to read: the association of visual form, sound, and meaning.

Visual discrimination matching of all the single letters which were constituents of the words to be learned later in a reading task tended to be better training than matching the same words, supporting that part of the present study which has a matching to sample design using letters.

King (1972) in a comparison of 27 early readers to 28 non-early readers found that intelligence, visual discrimination, letter recognition, word recognition, and rate of learning to read new words were the variables most important in differentiating between the two groups. She concluded that early instruction in these areas would assist in increasing reading skill.

Samuels and Jeffrey (1966, pp. 337-340) designed a study to test the relationship between the rate of learning and the number of letters, and, in addition, to evaluate the degree to which transfer was related to similarity as defined by number of letters used in the list.

The subjects were thirty-six kindergarten children from a Los Angeles school and twenty-four children from a Santa Monica nursery school.

The hypothesis that stimulus similarity would prove to be a relatively important factor in paired-associate learning, if the stimuli were unfamiliar and children used as subjects, received strong support although it was also shown that with specialized training, the effect of stimulus similarity on learning was reduced considerably. The results indicated that the number of subjects who made identifications on the basis of a single letter increased with the number of letters on which they were trained. Thus, training that forced attention to each letter was less likely to lead to subsequent reading errors than training which permitted the child to identify words on the basis of a single feature. In letter discrimination training, more attention would need to be given towards efficient discrimination of confusable letters.

IV. SUMMARY

This chapter has been concerned with Money's theory of visual discrimination, and a review of relevant research in visual discrimination of letters and words. It was indicated that a purpose of this study was to determine whether there is any significant difference in the ability to discriminate between letters of formal similarity and reversible letters. Significant differences may support Money's Laws of Constancy.

The research indicated, on the whole, that the discrimination of letters and words was vital to reading improvement. Research was consistent in finding that of the letters most confusing to children, reversible letters were most problematic.

CHAPTER III

THE EXPERIMENTAL DESIGN

I. INTRODUCTION

This chapter reports the selection of the test sample, describes the construction of the research instruments and the pilot study. The procedures followed in the collection and treatment of the data follow.

II. SELECTION OF THE SAMPLE

The data for the present study were gathered from pupils in kindergarten, grade one, and grade two, from a public school in St. John's, Newfoundland, in March, 1967. The sample of seventy-five pupils selected for this study was chosen from fifty-five kindergarten pupils, one hundred grade one pupils, and one hundred grade two pupils which represented pupils in these grades in the city of St. John's. In St. John's there are a variety of schools of various religious denominations. Some of the schools are all boys' schools, and some are all girls' schools. Also the pupils of some schools generally come from homes of lower socio-economic status, and the pupils of other schools come from homes of higher socio-economic status. With the help and advice of supervisors from local school boards, the investigator selected a school that was co-educational, and that reflected a wide distribution of socio-economic status.

The 255 pupils were selected because as primary pupils they were involved in the acquisition of visual discrimination skills in learning to read. Three grades were selected so that one might determine what significant differences, if any, might exist between the groups in their abilities to discriminate letters. A second kindergarten shift attended the school in the afternoons, but this investigator was able to come to the school during mornings only, so this particular shift was not considered in the study. There were a total of one hundred and ten kindergarten children attending this school, of which fifty-five attended a morning shift and fifty-five an afternoon shift.

The sample of pupils for this study was selected randomly from within the school used for the study and was stratified by grade, kindergarten, grades one and two. Originally ninety pupils were selected with thirty from each grade, however, because of absenteeism in the grades, this number was reduced to twenty-five pupils from each of the three grades.

III. CONSTRUCTION OF THE VISUAL DISCRIMINATION TESTS

Since it had been decided to assess visual discrimination ability by observing children's abilities to discriminate between letter pairs of proven difficulty, the problem of selecting a test design was not unduly difficult. The letter pairs of proven difficulty observed by Popp (1964) were chosen for this study along with a simple matching to sample design. Popp had prepared projection slides and tested children individually, and this procedure was adapted to a pencil-and-paper matching test which could be administered to the primary pupils.

There are a variety of methods for using a sample and matching design. It was decided to use a single distractor. This seemed reasonable since it would be a clear empirical indication of the task set by the test items, thus, it would lend itself readily to analysis. If a number of differing distractors were used in test items, the task of analysing errors would be extremely difficult. For example, using a number of distractors one could not be certain that the difficulty of the task set in the test items would not interfere with the discrimination task. On the other hand, the simplicity of the single distractor test design would render the visual discrimination task understandable to a kindergarten child. Therefore, it was decided to have the stimulus item on the left, and the item and the distractor placed on the right. The selection of one distractor for each test item would increase the probability of guessing and thus limit test reliability. To reduce this possibility the length of the tests was increased by repeating the similar letter pairs twice and the reversed letter pairs four times on tests one through to eight. The reversed letter pairs were repeated more frequently than the similar letter pairs because there were fewer and Popp's study (1964) illustrated that they were confused more often than the similar letter pairs. The problem as to the order of the two items on the right was of concern only to the extent of ensuring that no regular pattern of selection could be readily discernible. This was accomplished by using the other of the two positions for the distractor in the second item testing a confusable letter.

Since the uniformity of the changes in the placement of the distractor might lessen the significance of all of the tests because of pupil observation of this pattern, intelligence could be a factor; therefore, where those tests were considered, the effects of intelligence were controlled statistically.

The ten visual discrimination tests were divided into two groups, similar letter pairs and reversed letter pairs. The designs of each of the ten tests were identical; each test question contained an item to be identified by matching it with an identical item, and a distractor. The only difference between the distractor and the test item was the change of position of the letters of proven difficulty.

Once the decision to use a pencil and paper test was determined, the format of the test had to be decided. Two designs were chosen as described below and as illustrated in Appendix 2 and three tests were constructed each using both designs, a total of six tests. These six tests were administered in a pilot study to ten kindergarten and grade one children. These children were from the same school as that chosen for the study, but they were not included in the main study. It was found that the children could competently use both designs. The second design was chosen for the study since the letters were smaller and therefore closer to the usual word recognition of a printed page.

The first design differed from the second design in two ways. First, the letters of the first design were slightly larger than primary print. The letters of the second design were those of a primary typewriter in size. Second, the items on the first design were completely separated from each other by connecting lines in a box-like form. The boxes in the second design were connected from one item to the next by some common lines. Since the second design was selected for this study the tests in Appendix 1 are examples of the second design.

Validity of the Tests

The validity of a test depends upon the fidelity with which it measures what it purports to measure. It is reasoned that The Visual Discrimination Tests have content and construct validity. The tests have content validity at least for kindergarten children because the letters selected for the study were found by Popp (1964) to be confusable for kindergarten age children. Both groups of letters were located in words and nonsense syllables in order to determine whether this would render accurate discrimination of these letters more difficult. Nonsense syllables were selected in order to expose the children to unfamiliar letter groups in an effort to minimize the role of meanings as cue to assist in making the correct choice.

The tests are reasoned to have construct validity because the test design is basically a matching to sample design as was that used by Popp (1964). It is consistent and relatively simple to suit primary children. There is but one distractor in each test item, and the only change in the distractor is in the alternating of a letter of the confusable pair.

Tests IX and X were concerned with similar letter pairs and reversed letter pairs in longer words. Longer words would contain four to seven letters. In Tests III to VIII inclusive where letters were imbedded in shorter words and nonsense syllables of three letters, the letters were imbedded uniformly in initial, medial and final positions throughout the tests. Tests I and II contained similar and reversed letter pairs in isolation. It was decided to construct Tests IX and X on the same pattern as the preceding eight tests. Also in Tests IX and X it was decided to use each pair of confusable letters at least once on the tests and some letter pairs twice. This information is summarized in Table I in Chapter I.

IV. THE PILOT STUDY

A pilot study for the purpose of testing the suitability of the procedures planned for this experiment was conducted in November, 1966 in the school at which it was decided to conduct the main part of the study. Three tests of similar letter pairs and three tests of reversible letter pairs were administered by the researcher. It was found that the five kindergarten children and the five grade one children could competently cope with the design having had some experience with matching procedures and it was assumed grade two children would have no problems either with the design. Other changes to The Visual Discrimination Tests were described in the previous section. The ten children used in the pilot were not included in the main study. At this time, November, 1966, it was decided to conduct the main experimental study in March, 1967, since at this time the kindergarten children would have had a beginning reading program for two months should know a number of sight words as well as have a knowledge of all the letters of the alphabet.

Despite the near perfect test performance by the children in the pilot study on Tests I and II, it was decided to go ahead with the main study since the number of children in the pilot study was so restricted.

V. DATA COLLECTION

All tests were group tests and were administered in the main experiment by the investigator with the help of six assistants. Meetings were held with the assistants to prepare them for their part in the experiment. The size of the groups varied for the intelligence tests. At the kindergarten level, groups of nine were tested, at the grade one level, groups of eleven were tested, and at the grade two level, the group was divided into two sections of fifteen pupils each and each section was tested separately.

The directions for administration of The Gates Word Recognition Test and The Lorge-Thorndike Intelligence Tests were contained in the manual of directions enclosed with these tests, and were followed exactly by all test administrators. The tests were administered in order from one to ten over a period of several days. Since the visual discrimination tests were short and were administered in two consecutive morning sessions of about a half hour duration, the acquisition of visual discrimination skill during this period of time would be limited. All tests were administered during the period from nine to ten-thirty in the morning. All children were given sufficient time to complete all tests. The approximate administration time per test was about ten minutes a total of one hundred minutes for all ten of The Visual Discrimination Tests.

The directions for administration of the ten visual discrimination tests were very simple, and once understood the same procedure was used for each test. The students were told to look at the sample item on the bottom of the title page. At the front of the class the administrator had a copy of the test and pointed out the item to the group. The particular sample was then written on the board. The administrator told the students to look at the letter or letters on the left pointing at the same time to the blackboard at the particular item written there. Then the students were told to pick from the two items on the right the item that looked most like the one on the left. They were then told to put a circle around the item that they had picked. The administrator and assistants then checked to see that all understood these directions. Following this, the students were told that the questions on the test were very much like the one they had just answered. With each question they were to look at the item on the left and then circle the item most like it. The visual discrimination tests were not timed.

VI. SCORING AND TESTING

All tests were scored by the investigator and his assistants. One point was given for each correct response on The Visual Discrimination Tests, and the total correct responses for each test became the final score for that test. The scoring was the same for all visual discrimination tests. The student was required to look at the stimulus item on the left and to circle the matching item on the right. If he circled the correct item he received one point. The word recognition and intelligence tests were scored as directed in accompanying manuals.

VII. ANALYSIS OF DATA

The analysis of this experimental data was by an applied multiple linear regression as developed by Bottenberg and Ward (1962). Applied multiple linear regression analysis was to determine the significance of the visual discrimination of selected letter in the presence of other letters. This was accomplished by two models, the one containing the letters selected for analysis, and the second without it. The resultant comparison between the two models determined the degree of significance of those confusable letters in predicting reading achievement.

VIII. SUMMARY

A test sample of seventy-five pupils from kindergarten, grade one, and grade two from a public school in St. John's, Newfoundland was selected for this study. Administered to this sample were the following: The Lorge-Thorndike Intelligence Tests, The Gates Word

Recognition Tests, and The Visual Discrimination Tests. This chapter described the test sample, the construction of The Visual Discrimination Tests, the pilot study, and procedures for data collection and analysis.

CHAPTER IV

THE FINDINGS

Chapter IV is divided into three parts: firstly, a summary of pupil performance on *The Lorge-Thorndike Intelligence Tests*, *The Gates Word Recognition Test*, and *The Visual Discrimination Tests* is given; secondly, a report of the findings from the analyses of the test scores using multiple linear regression is made and thirdly, a discussion of the findings is presented.

I. PUPIL PERFORMANCE

A summary of the means and standard deviations on intelligence, word recognition and visual discrimination tests which represent the performance of pupils in kindergarten, grade one, grade two and the total test sample is presented in Table II.

The mean chronological age increased with grade level; however, as the table shows there was only a fraction of a month difference between the mean age of pupils in grade one, and those in grade two. The standard deviation at the grade two level was large, much more so than that at the kindergarten and grade one levels and indicated a number of pupils there were both younger and older than

TABLE II

MEANS AND STANDARD DEVIATIONS OF TEST SCORES AND AGES OF PUPILS

PERFORMANCE OF PUPILS IN:

	TOTAL POSSIBLE SCORE	KINDERGARTEN		GRADE I		GRADE II		TOTAL TEST SAMPLE	
		MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
Chronological Age (Month)		67.80	3.86	79.00	3.75	79.80	28.50	75.49	17.73
The Lorge-Thorndike Intelligence Tests		105.96	11.01	103.13	12.23	99.12	11.86	102.73	12.04
The Gates Word Recognition Test	48	3.48	4.37	28.88	12.03	43,04	6.07	25.43	18.36
The Visual Discrimination Tests:									
Test I	18	14.48	4.05	15.88	.33	15.96	.20	15.43	2.46
Test II	24	22.52	2.28	23.67	1.07	23.92	.27	23.36	1.59
Test III	18	17.4	.75	17.88	.44	17.92	.39	17.73	.60
Test IV	18	17.12	2.49	17.63	1.03	17.92	.39	17.55	1.61
Test V	18	16.72	1.97	17.75	.52	17.64	1.38	17.26	1.50
Test VI	24	21.08	2.99	23.04	1.65	24.00	.00	22.70	2.32
Test VII	24	22.92	1.55	23.08	1.47	23.68	.84	23.23	1.36
Test VIII	24	22.0	3.72	23.25	1.98	23.8	.40	23.01	2.57
Test IX	15	12.8	3.10	14.00	1.6	14.72	.66	13.83	2.21
Test X	15	12.0	3.38	13.88	1.99	14.76	.51	13.54	2.56

normally found. An expected range of ages at the kindergarten and grade one levels was indicated.

The mean intelligence score decreased slightly with increase in chronological age, and the standard deviation was comparable at all three grade levels. The mean intelligence score and the standard deviation at the grade two level indicated the presence of older but less intelligent pupils.

The means of the scores of The Gates Word Recognition Test increased as the grade levels advanced. It should be noted that at the kindergarten level the mean score was 3.48 with a standard deviation of 4.37 indicating that a number of children may not have scored on this test. This finding was surprising since these children were well into a pre-reading program and both the school principal and the teacher stated that all should score.

At the grade one level the mean score was 28.8 with a standard deviation of 12.03 illustrating a wide range of achievement, with an overlap of the highest grade one achievers with the lowest grade two achievers. At the grade two level the mean was 43.04 and the standard deviation was 6.07 showing some pupils at the grade two level may have had perfect scores. That a small number of the grade two pupils may have obtained perfect scores on the word recognition test was interesting in that there was also a large standard deviation in the age variable at this grade level. It should be noted that the norms published in the test manual showed this test was suitable for American pupils at the 2.6 grade level.

On *The Visual Discrimination Tests* the means of pupil scores increased and the standard deviations decreased with increase in grade level. Pupils at the kindergarten, grades one and two levels obtained high scores but there was a small but measurable increase in achievement with increase in grade. At the kindergarten level standard deviations ranged from 4.05 for Test I down to .75 for Test III, at the grade one level from 1.98 for Tests VIII to .44 for Test III, and at the grade two level from 1.38 for Test V to .00 for Test VI. The cluster around the mean underline the high scoring of pupils on these tests.

II. ANALYSES

In this study the predictor variables which accounted for an amount of the variance of the criterion variable were the scores of *The Visual Discrimination Tests*. The Criterion variable was the scores of *The Gates Word Recognition Test* used to measure pupil achievement in reading.

The variance accounted for by both sex and intelligence were controlled in Hypotheses I, II, III and IV.

The investigator was concerned with assessing whether significant differences existed between pupil scores on The Visual Discrimination Tests for predicting success on The Gates Word Recognition Test; therefore, tests had to be compared "in the presence of" other tests. That is, the visual discrimination tests were compared in the presence of one another for the majority of the tests. If a visual discrimination test in the presence of another visual discrimination test did significantly predict achievement on The Gates Word Recognition Test, this would mean that the pupils' ability to perform on the particular visual discrimination test differed significantly from the other discrimination test which was also present in the model pointing out that a different skill was being tested.

Results of the analyses are reported by grade. The third section of the chapter will discuss the findings and suggest the strands of a developmental pattern.

Kindergarten

Table III reports the probability of The Visual Discrimination Tests predicting achievement on The Gates Word Recognition Test for the kindergarten group.

TABLE III

PROBABILITY OF THE VISUAL DISCRIMINATION TESTS PREDICTING ACHIEVEMENT ON THE GATES WORD RECOGNITION TEST FOR THE KINDERGARTEN GROUP

Prediction Variable	In the Presence of	Criterion Variable	F. Ratio	Probability
Similar Letter Pairs				
Test IV	Test III	The Gates Word Recognition Test	4.6037	*.03537
Test III	Test IV	"	1.4329	.23533
Test V	Test III	"	6.1594	*.01547
Test III	Test V	"	8.0515	**.00594
Test V	Test IV	"	.3895	.53457
Test IV	Test V	"	5.3404	*.02379
Test IX	Test X	"	8.3574	**.00507
Reversed Letter Pairs				
Test VII	Test VI	"	.2431	.62352
Test VI	Test VII	"	8.6297	**.00445
Test VIII	Test VI	"	8.2938	**.00527
Test VI	Test VIII	"	4.0732	*.04740
Test VIII	Test VII	"	13.4797	**.00047
Test VII	Test VIII	"	.5466	.46216
Test X	Test IX	"	3.3924	.06961
Tests IX, I, III, IV, V	Tests X, II, VI, VII, VIII	"	.2209	.63974
Tests II, VI, VII, VIII and X	Tests III, IV, V, IX and I	"	2.2178	.14079
Test I to X	Intelligence	"	5.5539	*.02116

* - Significant at the .05 level -
** - Significant at the .01 level -

Similar letter pairs. Each of the visual discrimination tests of similar letter pairs, Tests III, IV, V, and IX, accounted for a significant amount of the variance of scores at either the .01 or the .05 levels of significance with the exception of Test III in the presence of Test IV and Test V in the presence of Test IV.

This would indicate that the visual discrimination tests, Tests III, IV, V, and IX, would predict achievement on The Gates Word Recognition Test except as noted above.

Reversed letter pairs. Each of the visual discrimination tests of reversed letter pairs, Tests VI, VII, VIII, and X, accounted for a significant amount of the variance of scores at either the .01 or the .05 levels of significance with the exception of Test VII in the presence of Tests VI and VIII.

Indications were that the visual discrimination tests, Tests VI, VIII, and X, would predict achievement on The Gates Word Recognition Test.

Similar and reversed letter pairs. All of the tests of similar letter pairs together, Tests I, III, IV, V, and IX, and all of the tests of reversed letter pairs together, Tests II, VI, VII, VIII, and X did not account for a significant amount of the variance of pupil scores.

At the kindergarten level neither the five tests of similar letter pairs in the presence of the five tests of reversed letter pairs, nor the same tests of reversed letter pairs in the presence of the same tests of similar letter pairs would predict achievement on The Gates Word Recognition Tests.

Visual discrimination total score and intelligence. All ten visual discrimination tests in the presence of intelligence accounted for a significant amount of the variance of scores at the .05 levels of significance on The Gates Word Recognition Test. Even when factors of intelligence were controlled statistically the ten visual discrimination tests considered together predicted achievement on The Gates Word Recognition Test for kindergarten pupils.

Grade One

Table IV illustrates the probability of The Visual Discrimination Tests predicting achievement on The Gates Word Recognition Test for the grade one group.

Similar letter pairs. The visual discrimination tests of similar letter pairs, Tests III, IV, V, and IX, accounted for a significant amount of the variance of scores at either the .01 or the .05 levels of significance with the exception of Test III in the presence of Tests IV and V and Test IV in presence of Test V.

These visual discrimination tests, Test IV, V, and

TABLE IV

PROBABILITY OF THE VISUAL DISCRIMINATION TESTS PREDICTING ACHIEVEMENT ON THE GATES WORD RECOGNITION TEST FOR GRADE ONE

Prediction Variable	In the Presence of	Criterion Variable	F. Ratio	Probability
Similar Letter Pairs				
Test IV	Test III	The Gates Word Recognition Test	4.4969	*.03750
Test III	Test IV	"	.4146	.52174
Test V	Test III	"	12.7442	**.00065
Test III	Test V	"	2.3572	.12921
Test V	Test IV	"	7.9164	**.00635
Test IV	Test V	"	2.0856	.15315
Test IX	Test X	"	14.6714	**.00027
Reversed Letter Pairs				
Test VII	Test VI	"	6.9978	**.01007
Test VI	Test VII	"	.0000	1.00000
Test VIII	Test VI	"	7.3355	**.00849
Test VI	Test VIII	"	7.0228	**.00994
Test VIII	Test VII	"	.3069	.58133
Test VII	Test VIII	"	7.0228	**.00994
Test X	Test IX	"	.0568	.81227
Test IX, III, IV, V, I	Test VIII, X, VI, VII, II	"	14.9428	**.00024
Test X, II, VI, VII, VIII	Test IX, I, III, IV, V	"	1.15749	**.28560
Tests I to X	Intelligence	"	7.1633	**.00921

* - Significant at .05 level -
** - Significant at .01 level -

IX then, would predict achievement on The Gates Word Recognition Test except as noted above.

Reversed letter pairs. The visual discrimination tests of reversed letter pairs, Tests VI, VII, VIII and X accounted for a significant amount of the variance of scores at the .01 level of significance with the exception of Test X in the presence of Test IX, Test VI in presence of Test VII, and Test VIII in presence of Test VII.

Indications were that the visual discrimination tests of reversed letter pairs, Tests VI, VII, and VIII would predict achievement on The Gates Word Recognition Test except as noted above.

Reversed and similar letter pairs. All of the tests of similar letter pairs, Test I, III, IV, V, and IX, accounted for a significant amount of the variance of pupil scores at the .01 level of significance but all the tests of reversed letter pairs, Tests II, VI, VII, VIII, and X, in the presence of the tests of similar letter pairs did not.

At the grade one level the tests of similar letter pairs considered together are significant in predicting achievement on The Gates Word Recognition Test. However, all of the tests of reversed letter pairs considered together when in the presence of all of the tests of similar letter pairs would not predict achievement on The Gates Word Recognition Test.

Visual discrimination total score and intelligence. All ten visual discrimination tests in the presence of intelligence accounted for a significant amount of the variance of scores at the .01 level of significance.

This would indicate that at the grade one level even when factors of intelligence were controlled the visual discrimination tests considered together would predict achievement on The Gates Word Recognition Test.

Grade Two

Table V illustrates the probability of The Visual Discrimination Tests predicting achievement on The Gates Word Recognition Test for the grade two group.

Similar letter pairs. Only the visual discrimination test, Test III, would predict achievement on The Gates Word Recognition Test except as noted above.

Reversed letter pairs. The visual discrimination tests of reversed letter pairs, Tests VI, VII, VIII, and X accounted for a significant amount of the variance of scores at either the .01 level of significance with the exception of Test X in the presence of Test IX, Test VI in the presence of Test VII and Test VIII in the presence of Test VII.

The visual discrimination tests of reversed letter pairs, Test VI, VII, VIII, predicted achievement on The Gates

TABLE V

PROBABILITY OF THE VISUAL DISCRIMINATION TESTS PREDICTING ACHIEVEMENT ON THE GATES WORD RECOGNITION TEST FOR GRADE TWO

Prediction Variable	In the Presence of	Criterion Variable	F. Ratio	Probability
Similar Letter Pairs				
Test IV	Test III		1.5014	.22456
Test III	Test IV		2.2930	.13446
Test V	Test III		1.5638	.21527
Test III	Test V		3.8343	* .05420
Test V	Test IV		.0107	.97781
Test IV	Test V		1.4410	.23402
Test IX	Test X		.9837	.32460
Reversed Letter Pairs				
Test VII	Test VI		6.9978	**.01007
Test VI	Test VII		.0000	1.00000
Test VIII	Test VI		7.3355	**.00849
Test VI	Test VIII		7.0228	**.00994
Test VIII	Test VII		.3069	.58133
Test VII	Test VIII		7.0228	**.00994
Test X	Test IX		.3163	.57556
Tests III, IV, V, I, IX	Tests VI, VII, VIII, II, X		.4615	.49912
Tests X, II, VI, VII, VIII	Tests IX, I, III, IV, V		10.4087	**.00189
Tests I to X	Intelligence		.7695	.38328

* - Significant at .05 level -
** - Significant at .01 level -

Word Recognition Test except as noted above.

Similar and reversed letter pairs. All tests of reversed letter pairs together, Tests II, VI, VII, VIII, and X, accounted for a significant amount of the variance of scores at the .01 level of significance. The tests of similar letter pairs together in the presence of the tests of reversed letter pairs were not significant.

This would indicate at the grade two level these tests of reversed letter pairs considered together were significant in predicting achievement on The Gates Word Recognition Test. However, all the tests of similar letter pairs considered together when in the presence of all of the tests of reversed letter pairs did not predict achievement on The Gates Word Recognition Test.

Visual discrimination total score and intelligence. All ten visual discrimination tests in the presence of intelligence did not account for a significant amount of the variance of scores at the .05 level of significance.

When intelligence are taken into consideration the visual discrimination tests considered together will not predict achievement on The Gates Word Recognition Test for grade two pupils.

Total Test Sample

Table VI illustrates the probability of The Visual

TABLE VI

PROBABILITY OF THE VISUAL DISCRIMINATION TESTS PREDICTING ACHIEVEMENT ON THE GATES WORD RECOGNITION TEST FOR THE TOTAL TEST SAMPLE

Prediction Variable	In the Presence of	Criterion Variable	F. Ratio	Probability
Similar Letter Pairs				
Test IV	Test III		1.3675	.24621
Test III	Test IV		11.4509	**.00117
Test V	Test III		2.1161	.15023
Test III	Test V		10.6633	**.00169
Test V	Test IV		2.867	.09486
Test IV	Test V		1.4133	.23852
Test IX	Test X		2.3662	.12837
Reversed Letter Pairs				
Test VII	Test VI		1.7376	.19174
Test VI	Test VII		20.7032	**.00002
Test VIII	Test VI		1.8858	.17406
Test VI	Test VIII		20.9456	**.00002
Test VIII	Test VII		6.0569	* .01632
Test VII	Test VIII		6.1026	* .01594
Test X	Test IX		3.8461	* .05373
Tests I, IX, III, IV, V	Tests II, X, VI, VII, VIII		1.4193	.23742
Tests II, VI, VII, VIII, X	Tests I, III, IV, V, IX		8.0503	**.00591
Tests I to IX	Intelligence		32.3502	**.00000

* - Significant at .05 level -
** - Significant at .01 level -

Discrimination Tests predicting achievement on The Gates Word Recognition Test for the total test sample.

Similar letter pairs. The visual discrimination tests of similar letter pairs, Test III, accounted for a significant amount of the variance of scores at the .01 level of significance. Test IV in the presence of Tests III and V, Test V in the presence of Tests III and IV, and Test IX in the presence of Test X were not significant.

This would indicate that the visual discrimination test, Test III, would predict achievement on The Gates Word Recognition Test.

Reversed letter pairs. The visual discrimination tests of reversed letter pairs, Tests VI, VII, VIII, and X, accounted for a significant amount of the variance of scores at either the .01 or .10 levels of significance except Test VII in the presence of Test VI and Test VIII in the presence of Test VI.

The visual discrimination tests of reversed letter pairs, Tests VI, VII, VIII, and X would predict achievement on The Gates Word Recognition Test except as noted above.

Reversed and similar letter pairs. All of the tests of reversed letter pairs together Tests II, VI, VII, VIII, and X, accounted for a significant amount of the variance of scores at the .01 level of significance but all of the tests of similar letter pairs together, Tests I, III, IV, V and IX, did not.

This would indicate for the total test sample that the tests of reversed letter pairs considered together were significant in predicting achievement on *The Gates Word Recognition Test*. However, all the tests of similar letter pairs considered together when in the presence of all of the tests of reversed letter pairs did not predict achievement on *The Gates Word Recognition Test*.

Visual discrimination total score and intelligence. All ten visual discrimination tests in the presence of intelligence accounted for a significant amount of the variance of scores at the .01 or .05 levels of significance.

For the Total Test Sample even when factors of intelligence were taken into consideration the visual discrimination tests considered together would predict achievement on *The Gates Word Recognition Test*.

Significance of Grade in the Presence of Similar and Reversed Letter Pairs

Table VII indicates the significance of grade in the presence of similar and reversed letter pairs in longer words.

TABLE VII

THE SIGNIFICANCE OF GRADE IN THE PRESENCE OF SIMILAR AND REVERSED LETTER PAIRS IN LONGER WORDS

Predictor Variable	In the presence of	Criterion Variable	F. Ratio	Probability
Grade	Test IX	The Gates Word Recognition Test	3.9984	.04837
Grade	Test X	The Gates Word Recognition Test	4.7954	.03182

Grade accounts for a significant amount of the variance of scores at the .05 level of significance even when an amount of the variance is accounted for by Tests IX and X.

This would indicate that in the primary grades, what grade a pupil is in would be significant in predicting achievement on The Gates Word Recognition Test even in the presence of an amount of the variance accounted for by the visual discrimination of similar and reversed letter pairs in longer words.

Correlation

The correlation between sex and visual discrimination total scores was not significant.

III. DISCUSSION OF FINDINGS

Discussing the findings is difficult because there were few discernible trends. However, comments are offered here on the analyses of the similar letter pairs, the reversed letter pairs, and the comparison between both of these groups of letters as summarized in Table VIII.

At the kindergarten and grade one levels it seems that ability to discriminate between letters similar in form was characteristic of good readers in this study. Furthermore, when the similar letter pairs were located close to one another in word context they became more difficult for the poorer readers to discriminate between them.

At the grade two level the ability to discriminate between similar letter pairs did not predict reading achievement. This suggests that the majority of the children in this study by mid-grade two were generally proficient in the discrimination of these [illegible]

The ability to discriminate between reversible letters was characteristic of good readers at the three grade levels of this study. The trend was for the ability to discriminate these letters to become somewhat more

TABLE VIII

SUMMARY OF SIGNIFICANCE OF DIFFERENCES IN PUPIL PERFORMANCE ON THE VISUAL DISCRIMINATION TESTS

GRADE	! Test III "IPO"		Test IV "IPO"		Test V "IPO"		Test IX "IPO"	Tests I, III, IV, V, IX "IPO"	Test VI "IPO"		Test VII "IPO"		Test VIII "IPO"		Test X "IPO"	Tests II, VI, VII, VIII, X "IPO"
	IV	V	III	V	III	IV	X	Tests II, VI, VII, VIII, X	VII	VIII	VI	VIII	VI	VII	IX	Tests I, III, IV, V, IX
K	NS	**	*	*	*	NS	**	NS	**	*	NS	NS	**	**	NS	NS
1	NS	NS	*	NS	**	**	**	**	NS	**	**	**	**	NS	NS	NS
2	NS	*	NS	NS	NS	NS	NS	NS	NS	**	**	**	**	NS	NS	**
TOTAL	**	**	NS	NS	NS	NS	NS	NS	**	**	NS	*	NS	*	*	**

! "IPO" - in presence of

* - Significant at .05 level

**- Significant at .01 level

NS - not significant

reliable in predicting reading achievement at the grade two level than at the kindergarten and grade one levels. Further, imbedding these reversible letters in words tended to increase their confusability at all three grades more so than imbedding similar letter pairs in words.

An additional interesting observation may be made on the comparison of these pupils' test scores of similar letters and those of reversed letters. It may be observed that at the kindergarten level pupil ability to discriminate both groups of letters was equally reliable in predicting reading achievement. At the grade one level the ability of pupils to discriminate similar letters was more reliable in predicting reading achievement than the ability to discriminate between reversed letters, but the opposite was true at the grade two level. From kindergarten to grade two, then, ability to discriminate similar letters decreased in importance for predicting reading advancement while ability to discriminate reversed letters increased in importance. The discriminating of likenesses and differences in similar letter pairs was not as difficult a task as discriminating reversed letter pairs for these children. Also the visual discriminating of both letter groups was more difficult for them when they were located in words.

CHAPTER V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS FOR FURTHER RESEARCH

I. OVERVIEW OF THE STUDY

The purpose of this study was to further investigation initiated by Popp (1964) covering confusability in discriminating certain pairs of alphabet letters. The present study was concerned with determining whether there were significant differences among primary grade children in their ability to discriminate similar and reversible letters and whether differences would predict achievement on a word recognition test. A further purpose of the study was to determine whether the confusability of letters would change according to location in a word.

Ten visual discrimination tests of identical design were constructed with each test item containing one distractor. The only variable in each test item was the alternating of the letter in each confusable pair. The test items ranged in difficulty from letters in isolation to letters located in words and to nonsense syllables from three to seven letters. Significant differences were ascertained by observing the scores of one visual discrimination test in the presence of another visual discrimination test. The criterion variable was a word recognition test, The Gates Word Recognition Test.

A pilot study was conducted with five kindergarten and five grade one children, in order to test the suitability of the materials and procedures planned for the study. The data for the present study was gathered from seventy-five pupils, twenty-five in each of kindergarten, grade one, and grade two, from a public school in St. John's, Newfoundland. All tests were group tests and were administered in the main experiment by the investigator with the help of six assistants. The analyses of the experimental data were by Applied Multiple Linear Regression.

II. SUMMARY OF MAIN FINDINGS

The findings indicated that the tests of similar letter pairs were more frequently significant than not significant at the kindergarten and grade one levels, but not at the grade two level, in predicting achievement on The Gates Word Recognition Test. The tests of reversed letter pairs were generally not significant at the kindergarten and grade one levels but were significant frequently at the grade two level in predicting achievement on The Gates Word Recognition Test.

The findings also indicated that with increase in grade there was an increasing competency in the visual discrimination of similar and reversed letter pairs. When factors attributed to intelligence were controlled, the pupil performance on the visual discrimination tests was still very high.

The main findings are summarized as they related to each hypothesis.

Hypothesis I

When differences attributed to intelligence and sex are controlled, there is no significant difference between a child's ability to discriminate selected similar letter pairs on each of Tests III, IV, V, and his score on The Gates Word Recognition Test:

(a) for the total sample
(b) for kindergarten children
(c) for grade one children
(d) for grade two children

At the grade two level, generally, the ability of children to discriminate similar letter pairs was more frequently not significant than significant in predicting success on The Gates Word Recognition Test.

At the kindergarten and grade one levels, generally, the ability to discriminate these letter pairs was significant in predicting success on the word recognition test.

Hypothesis II

When differences attributed to intelligence and sex are controlled, there is no significant difference between a child's ability to discriminate selected reversed letter pairs on each of Tests VI, VII, VIII, and his score on The Gates Word Recognition Test:

(a) for the total test sample

(b) for kindergarten children

(c) for grade one children

(d) for grade two children

At the kindergarten and grade one levels, generally, the difference in the abilities of pupils to discriminate reversed letter pairs was frequently significant in predicting achievement on The Gates Word Recognition Test.

At the grade two level, generally, the ability to discriminate reversed letter pairs was more frequently significant in predicting success on The Gates Word Recognition Test.

Hypothesis I and II assessed the confusability of similar and reversed letter pairs when these letters were located in three letter words, nonsense syllables, and three letter nonsense syllables where the sequence of these letter pairs was altered in the distractor. Pupil ability to discriminate letters of form similarity at the grade one level, and reversible letters at the grade two level did predict reading achievement.

Hypothesis III

There is no significant difference between a child's ability to discriminate selected similar letter pairs (total score of Tests I, III, IV, V, IX) from his ability to discriminate selected reversed letter pairs (total score of Tests II, VI, VII, VIII, X) as reflected in scores on The Gates Word Recognition Test:

(a) for the total test sample

(b) for kindergarten children

(c) for grade one children

(d) for grade two children

At the kindergarten level, the ability generally to discriminate between similar letter pairs and reversed letter pairs was not significant in predicting success on The Gates Word Recognition Test.

At the grade one level, the ability to discriminate similar letter pairs, but not reversed letter pairs, was significant in predicting success on The Gates Word Recognition Test. At the grade two level, the ability to discriminate reversed letter pairs, but not similar letter pairs, was significant in predicting success on The Gates Word Recognition Test.

Hypothesis IV

There is no significant difference between a child's ability to discriminate selected similar letter pairs located in longer words (score of Test IX) from his ability to discriminate selected reversed letter pairs in longer words (score of Test X) as reflected in scores on The Gates Word Recognition Test:

(a) for the total test sample
(b) for kindergarten children
(c) for grade one children
(d) for grade two children

At the kindergarten and grade one levels, the ability to discriminate similar letter pairs in longer words, but not reversed letter pairs in longer words, was significant in predicting success on The Gates Word Recognition Test.

At the grade two level, the ability to discriminate reversed letter pairs in longer words, but not similar letter pairs in longer words, was significant in predicting success on The Gates Word Recognition Test.

Hypothesis V

The scores of the children on all of the tests intended to measure the ability to discriminate selected letter pairs (total score of Tests I to X) do not account for a significant amount of the variance of the scores on The Gates Word Recognition Test beyond that difference accounted for by intelligence:

(a) for the total test sample

(b) for kindergarten children

(c) for grade one children

(d) for grade two children

At the kindergarten and grade one levels the ability to discriminate confusable letters was significant in predicting success on The Gates Word Recognition Test. At the grade two level, the visual discrimination total score was not significant in predicting success on the same word recognition test.

Hypothesis VI

Grade does not account for a significant amount of the variance of scores on The Gates Word Recognition Test beyond that variance accounted for by the scores of the children in the tests intended to measure the ability to discriminate selected letter pairs in longer words (scores of Tests IX and X).

Grade accounted for a significant amount of the variance of the score beyond the ability to discriminate between similar letter pairs and reversed letter pairs in predicting success on The Gates Word Recognition Test.

Hypothesis VII

There is no relationship between sex and visual discrimination (total scores of The Visual Discrimination Tests).

No significant relationship was found between visual discrimination and sex.

III. CONCLUSIONS

The conclusions are restricted to the test sample of this study, a relatively small number of children at three primary grade levels, and any other similar group of children. Also, other variables not controlled by the research design and procedures may have influenced the test scores, further limiting the validity of the conclusions recorded.

Accurate visual discrimination of certain confusable letters in words seems to be important for adequate word recognition among primary grade pupils.

In general, errors among kindergarten pupils are common and are evenly divided between the visual discrimination of similar letters and reversible letters. Among grade one children errors in the visual discrimination of reversible letters are common; however, those more skilled in word recognition ability appear to have greater skill in the visual discrimination of similar letters. At the grade two level, pupils generally have uniformity of skill in the visual discrimination of similar letters; however, those more skilled in word recognition techniques appear to have greater skill in the discrimination of reversible letters.

The ability to discriminate similar letters is distinct from the ability to discriminate reversible letters because pupil competency to discriminate these letters increases with increase in grade level and reading achievement. It would seem also that the visual discrimination of reversible letters is a more complex task than that of similar letters. This is supported by the fact that among grade one children the more skilled in the visual discrimination of similar letters also seem to be more skilled in word recognition. Most grade one pupils, however, have insufficient skill in visual discrimination of reversible letters. At the grade two level, those more skilled in the visual discrimination of reversible letters also seem to be more skilled in word recognition at their grade level. Most of these pupils have skill in the discrimination of similar letters. At all grade levels, the confusability of both groups of letters increases when they are located in words.

In that this study does support that the perceptual task of discriminating similar letters may be distinct from the discriminating of reversible letters, Money's (1966) theory that these two distinct concepts need to be possessed by young children if they are to accurately perceive similar letters and reversible letters seem to be supported. The two concepts which Money refers to are form constancy and positional constancy. Form constancy dictates that alphabet letters to maintain their conventional roles in communicating meaning must not transform their shape except within certain prescriptions. Positional constancy refers to the fact that a letter, to retain its name and meaning must always be directionally oriented the same way.

IV. IMPLICATIONS

The conclusions of considerable research in visual perception have been applied to many readiness and beginning reading programs. In many of these programs attention is given to development of accurate visual discrimination skills of perceiving letters. Increased focus on visual discrimination problems of confusable letters is merited from the findings of this study.

Furthermore, for accurate visual discrimination of confusable letters children should participate in activities of graduated difficulty involving the visual discrimination of these confusable letters. An essential part of these activities would be discussions with children of the "likenesses" and "differences" of the graphic symbols.

In addition, attention of children should be directed to accurate visual discrimination of similar letters before that of reversible letters.

V. SUGGESTIONS FOR FURTHER RESEARCH

A test constructed for teachers of kindergarten, grades one and two to measure the development of the concepts of form and positional constancy and their relationship to letter confusability should be the subject of research.

Research concerning the development of curriculum materials which would sequentially develop visual discrimination skill of these confusable letters at primary grade levels should be of assistance to teachers.

An analysis of the frequency of these confusable letters in existing kindergarten, grades one and two programs would assist in specifying for teachers the extent to which these confusable letters may be exposed to young children.

VI. CONCLUDING STATEMENT

Accurate visual discrimination of letters and words is essential for word recognition. Similar and reversible letters are two distinct groups of letters that are confusable for some primary grade children; therefore, care should be exercised that primary grade children discriminate with accuracy these confusable letters.

BIBLIOGRAPHY

A. BOOKS

Gibson, Eleanor J. *Principles of Perceptual Learning and Development.* New York: Meredith Corporation, 1969.

Feldmann, Shirley Clark. *Visual Perception Skills of Children and Their Relation to Reading.* Ph.D. Thesis: Columbia University, 1961.

Francis, W. Nelson. *The Structure of American English.* New York: The Ronald Press Company, 1958.

Fergusen, George A. *Statistical Analysis in Psychology and Education.* New York: McGraw-Hill Book Company, Inc. 1959.

Money, John. (Ed.) *The Disabled Reader.* Boltman: The John Hopkins Press, 1966. Pp. 21-40.

Smith, Frank. *Understanding Reading.* New York: Rinehart and Winston, Inc. 1971.

Thurstone, L. L. *A Factorial Study of Perception.* Chicago: University of Chicago Press, 1944.

Vernon, M. D. *A Further Study of Visual Perception.* Cambridge: Cambridge University Press, 1954.

B. PERIODICAL ARTICLES

Barrell, Thomas G. "Visual Discrimination Tasks as Predicators of First Grade Reading Achievement." *The Reading Teacher,* Vol. 18: 276-282, 1965.

Blair, J. R. and Ryckman, D. B. "Visual Discrimination: Lower-case Letter Confusion." U. S. Department of Health, Education and Welfare, Office of Education. University Microfische, No. ED029770, 1969.

Bruner, J. S. "Neural Mechanisms in Perception." *Psychological Review.* 64:340-358. 1957.

Bruner, J. S. "On Perceptual Readiness." *Psychological Review*, 64: 123-152, 1957b.

Davidson, Helen P. "A Study of the Confusing Letters b, d, p and q." *Journal of Genetic Psychology*. No. 47 (1935). Pp. 458-468.

Durrell, Donald and Alice Nicholson. "Preschool and Kindergarten Expression." *Development in and Through Reading;* National Society for the Study of Education; University of Chicago Press (1961). Pp. 257-269.

Gates, I. A. "The Psychology of Reading and Spelling with Special Reference to Disability." *Contributions to Education*, No. 129. New York: Columbia University, 1922.

Gates, I. A. "A Study of the Role of Visual Perception, Intelligence and Certain Associative Processes in Reading and Spelling." *Journal of Educational Psychology*, 17: 433-453. 1926.

Gates, I. A. "An Experimental Evaluation of Reading Readiness Tests." *Elementary School Journal*, 39: 497-508. 1939.

Gates, I. A. "A Further Evaluation of Reading Readiness Tests." *Elementary School Journal*, 40: 577-591. 1940.

Gates, I. A., and Eloise Roeker. "A Study of Initial States in Reading by Preschool Children." *Teachers College Record*, 24: 469-488. 1923.

Gates, I. A., and G. L. Bond. "A Study of Factors Determining Success and Failure in Beginning Reading." *Teachers College Record*, 37: 678-685. 1936.

Gibson, Eleanor, J. Gibson, Anne Pick, and H. Osser. "A Developmental Study of Discrimination of Letter-like Forms." *Journal of Comparative and Physiological Psychology*, 55: 897-906. 1962.

Goins, Jean T. "Visual Perceptual Abilities and Early Reading Progress." *Supplementary Educational Monographs, No. 87*. University of Chicago Press, 1958.

Gorelick, M. G. "Effectiveness of Visual Form Training in a Pre-reading Program." *Journal of Educational Research*, 58: 315-318, 1965.

Harrington, Sr. M. J. and Donald Durrell. "Mental Maturity Versus Perception Abilities in Primary Reading." *Journal of Educational Psychology*, 46: 375-380. 1955.

Hill, Mary B. "A Study of the Success of Word Discrimination in Individuals Beginning to Read." *Journal of Educational Research,* 30: 487-500. 1936.

King, E. M. "Effects of Different Kinds of Visual Discrimination Training on Learning to Read Words." *Journal of Educational Psychology,* 55: 325-333. 1964.

King, E. M. "Learning to Read Words: An Experiment in Visual Discrimination." *Reading and Inquiry.* Proceedings of the Annual Conference, International Reading Association. Volume 10: 337-340. 1965.

King, E. M., and Siegmar Muehl. "Different Sensory Cues as Aids in Beginning Reading." *Reading Teacher,* Vol. 19: 163-168. 1965.

King, E. M., and Friesen, Doris T. "Children Who Read in Kindergarten." *Alberta Journal of Educational Research,* Vol. 18, No. 3: 147-161. 1972.

Kettmeyer, W. "Readiness for Reading." *Elementary English,* 24: 355-367. 1947.

Krise, E. Morley. "Reversals in Reading." *Elementary School Journal,* 49: 278-284. 1949.

Lynn, R. "Reading Readiness and the Perceptual Abilities of Young Children." *Educational Research,* 6: 10-15. 1963.

Malmquist, E. *"Factors Related to Reading Disabilities in the First Grade of the Elementary School."* Stockholm: Almquist and Wiksell. 1958.

Muehl, Siegmar and Ethel M. King. "Recent Research in Visual Discrimination: Significance for Beginning Reading." *Vistas in Reading.* Proceedings of the Annual Conference, International Reading Association. Vol. 11: 434-439. 1966.

Petty, Mary C. "An Experimental Study of Certain Factors Influencing Reading Readiness." *Journal of Educational Psychology,* 30: 215-230. 1939.

Popp, Helen M. "Visual Discrimination of Alphabet Letters." *The Reading Teacher.* Vol. 17, No. 4: 221-226. 1964.

Postman, Leo, and Mark R. Rosenweig. "Perceptual Recognition of Words." *Journal of Speech and Hearing Disorders,* 22: 1957.

Robinson, Helen M. "Sequential Development of Reading Abilities." *Supplementary Educational Monographs, No. 90.* 1960.

Samuels, S. J. and W. E. Jeffrey. "Discrimination of Words, and Letter Cues Used in Learning to Read." *Journal of Educational Psychology.* Vol. 57: 337-340. 1966.

Smith, Nila B. "Matching Ability as a Factor in First Grade Reading." *Journal of Educational Psychology.* 19: 560-571. 1928.

Smythe, P. C., Stennett, R. G., Hardy, M. and Wilson, H. R. "Developmental Patterns in Elementary Reading Skills: Visual Discrimination of Primary-type Upper-case Letters." Mimeograph, Board of Education, London, Ontario, 1970.

Smythe, P. C., Stennett, R. G., Hardy, M. and Wilson, H. R. "Developmental Patterns in Elemental Reading Skills: Knowledge of Upper-case and Lower-case Letter Names." *Journal of Reading Behavior.* Vol. 3, No. 3: 24-33. 1970.

Vernon, M. D. "Perception, Attention and Consciousness." *The Advancement of Science,* 62: 111-123. 1962.

Wheelock, Warren H., and Nicholas J. Silvaroli. "Visual Discrimination Training for Beginning Reading." *The Reading Teacher,* Vol. 21(2): 115-120. 1967.

C. UNPUBLISHED MATERIALS

Burke, Lillian Irene. *The Relationship Between Word Recognition Cues, Phonic Knowledge and Reading Achievement.* Unpublished M.Ed. Thesis. University of Alberta, 1973.

Pick, Anne Danielson. *Improvement of Visual and Tactual Form Discrimination.* Ph.D. Thesis, Cornell University, 1963.

Twohig, Brian Thomas. *An Investigation into the Relationship between Body Directionality and Reading Achievement of Grade One Children* Unpublished M.Ed. Thesis. University of Alberta, 1972.

Wheatley, M. V. *A Study of the Relationship Between Certain Visual Perceptual Abilities and Achievement in First Grade Reading.* Unpublished M.Ed. Thesis. University of Alberta, 1965.

APPENDIX 1

TEN VISUAL DISCRIMINATION TESTS

TEST 1

Similar Letter Pairs

Name ____________________

Age ____________

Birthday ______________

Grade ____________

Sex __________

School ____________________

Sample

a	s	a

h	u	h
l	i	l
y	k	y
u	t	u
c	c	e
n	h	n
y	h	y
k	j	k

h	u	h
l	i	l
y	k	y
u	t	u
c	c	e
n	h	n
y	h	y
k	j	k

u	h	u
i	i	l
k	y	k
t	t	u
e	c	e
h	h	n
h	y	h
j	k	j

TEST 11

Reversed Letter Pairs

Name ____________________

Age ____________

Birthday ________________

Grade ____________ ______

Sex ____________

School ________________

Sample

w	o	w

p	q	p
b	b	d
n	u	n
b	q	b
d	d	p
b	p	b
q	p	q
d	d	b
u	u	n
q	b	q

p	p	d
p	b	p
n	n	u
p	p	q
b	d	b
n	n	u
b	q	b
d	d	p
b	p	b
q	p	q
d	d	b

u	u	n
q	b	q
p	p	d
p	b	p

TEST III

Similar Letter Pairs Used as Initial Letters in Three Letter Words

Name ______________________________

Age ______________

Birthday ____________________

Grade _________

Sex ________________

School ______________ ________________

Sample

man	lan	man

hot	uot	hot
lot	lot	iot
keep	yeep	keep
tell	uell	tell
cap	cap	eap
dip	hip	dip
hip	nip	hip
hill	hill	yill
jump	kump	jump
up	up	hp
is	ls	is

yet	ket	yet
upon	upon	tpon
easy	casy	easy
heat	heat	deat
now	how	now
yes	yes	hes
kill	jill	kill

TEST IV

Similar Letter Pairs Used as Initial Letters in Nonsense Syllables

Name ______________________________

Age ______________

Birthday _____________________

Grade ___________________

Sex __________________

School ________________________________

Sample

lun	bun	lun

hal	ual	hal
ion	lon	ion
kan	kan	yan
tes	ues	tes
cli	eli	cli
dst	dst	hst
hia	yia	hia
jen	jen	ken
uos	hos	uos
lst	ist	lst
hxt	nxt	hxt

yns	kns	yns
ulo	ulo	tlo
ezi	czi	ezi
hti	hti	dti
nso	hso	nso
yol	hol	yol
ksi	ksi	jsi

Test V

Similar Letter Pairs Used Together in Three Letter Nonsense Syllables

Name ______________________

Age ______________

Birthday ______________________

Grade __________________

Sex ______________

School ______________________________

Sample

lun	nul	lun

hau	uah	hau
ils	ils	lis
kay	yak	kay
tsu	tsu	ust
cbe	ebc	cbe
dhi	ihd	dhi
hsn	hsn	nhs
hy	yh	hy
jik	kij	jik
uth	htu	uth
lsi	isl	lsi

yuk	yuk	kuy
uat	tau	uat
ebc	ebc	cbe
hod	doh	hod
noh	noh	hon
yih	hiy	yih
klj	jkl	klj

TEST VI

Reversed Letter Pairs Used as Initial Letters in Three Letter Words

Name ______________________________

Age ________________

Birthday ______________________

Grade ________________

Sex ______________________

School ______________________________

Sample

boy	goy	boy

pay	qay	pay
bet	bet	det
now	uow	now
bay	bay	qay
bun	pun	bun
do	po	do
quay	puay	quay
dull	dull	bull
not	not	uot
quiet	buiet	quiet
pay	bay	pay

pill	pill	dill
nest	uest	nest
point	qoint	point
best	best	dest
boy	boy	qoy
bat	pat	bat
pot	dot	pot
dale	pale	dale
pin	pin	bin
near	uear	near
quick	buick	quick

does	boes	does
quack	quack	puack

TEST VII

Reversed Letter Pairs Used as Initial Letters in Three Letter Nonsense Syllables

Name ________ ____________________________

Age ____________________

Birthday ___________________________

Grade ___________________________

Sex ______________________

School ______________ _ _ ____________

Sample

gls	kls	gls

prs	qrs	prs
bln	bln	pln
nsi	usi	nsi
bul	qul	bul
bas	bas	pas
dne	pne	dne
ute	ute	nte
pur	dur	pur
pst	pst	bst
qan	qan	ban
dol	bol	dol
nio	nio	uio

qir	pir	qir
prn	qrn	prn
bso	dso	bso
bni	qni	bni
bui	bui	pui
dti	pti	dti
ula	ula	nla
pnu	pnu	dnu
pir	bir	pir
qui	bui	qui
dnt	bnt	dnt
qll	pll	qll

TEST VIII

Reversed Letter Pairs Used Together in Three Letter Nonsense Syllables

Name ______________________

Age __________

Birthday ________________

Grade ____________

Sex ____________

School ______________

Sample

uow	wou	uow

piq	qip	piq
bed	deb	bed
baq	baq	qab
bip	pib	bip
dep	ped	dep
nou	uon	nou
qap	qap	paq
dib	bid	dib
qeb	qeb	beq
pib	bip	pib
pad	pad	dap

uin	niu	uin
pnq	qnp	pnq
bud	bud	dub
biq	qib	biq
bep	peb	bep
dup	dup	pud
nau	uan	nau
qip	qip	piq
deb	bed	deb
qab	baq	qab
pub	pub	bup

pid	dip	pid
uan	uan	nau

TEST IX

Similar Letter Pairs Used in Longer Words as Initial Letters, Medial Letters, and Final Letters

Name ______________________________

Age ______ ________

Birthday _________________

Sex ______________

School __________________________________

Grade ____________________

Sample

open	open	opan

heaven	ueaven	heaven
casual	cashal	casual
extend	extend	exuend
keeper	yeeper	keeper
passive	passive	passivc
easel	easei	easel
effort	cffort	effort
enhance	endance	enhance
asked	asked	asjed
away	awah	away
dilate	hilate	dilate

saying	sahing	saying
forth	fortu	forth
judge	judge	kudge
interest	interesu	interest

TEST X

Reversed Letter Pairs Used in Longer Words as Initial Letters, Medial Letters, and Final Letters

Name ______________________________

Age ______________

Birthday ____________________

Grade ______________

Sex ______________

School ____________________________________

Sample

trouble	trouble	trouqle

express	exqress	express
asked	askeb	asked
oven	oven	oveu
dipt	pipt	dipt
laurel	laurel	lanrel
produce	qroduce	produce
lamb	lamd	lamb
eldest	eldest	elpest
weep	weed	weep
behind	dehind	behind
product	propuct	product

queen	bueen	queen
bale	bale	dale
asleep	asleeq	asleep
fumble	fumqle	fumble

APPENDIX 2

THE TWO DESIGNS

FIRST DESIGN

h
l
y
u
c
n
y
k

u	h
i	l
k	y
t	u
c	e
h	n
h	y
j	k

SECOND DESIGN

h	u	h
l	i	l
y	k	y
u	t	u
c	c	e
n	h	n
y	h	y
k	j	k